Quantifying stream bed erosion – deposition using temperature time series data

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Monitoring is essential


Johns Hopkins/NCED, Marmot Dam Website: http://pages.jh.edu/~marmot/Dam_After.JPG

Other monitoring methods


Why temperature?

• Robust
• Economical
• Low power
• Telemetry
• Small and inconspicuous
New monitoring method: How does it work?

- Uses temperature as a tracer
- \( \kappa_e = \text{effective thermal diffusivity} \)

\[
\frac{\partial T}{\partial t} = \kappa_e \frac{\partial^2 T}{\partial z^2} - \frac{q}{\gamma} \frac{\partial T}{\partial z}
\]

\[ T = T_{\text{ave}} + A \sin(\omega t) \]

\[
T = \text{Constant}
\]
New monitoring method: Temperature tracer

\[ \eta = - \frac{\ln \left( \frac{A_2}{A_1} \right)}{\phi_2 - \phi_1} \]

\[ \kappa_e(t) = \frac{\omega \Delta z^2}{\Delta \phi(t)^2 \left( 1 + \eta(t)^2 \right)} \frac{\eta(t)}{A_2/A_1} \]

\[ \Delta z(t) = \Delta \phi(t) \sqrt{\frac{2\kappa_e}{\omega} \frac{1}{\eta(t)} + \eta(t)} \]
New monitoring method: Advantages

Explicitly predicts from measured temperature time series:

- Scour – deposition
- Surface – subsurface flux
- Effective thermal diffusivity
- Thermal regime of the sediment
- Temperature sensing is robust and economical
Laboratory experiment

Features:
• Cyclic source water temperature
• Controlled pore water flux
• Precise erosion and deposition
• Digital temperature sensing probe
Laboratory experiment: Data analysis

Boundary conditions important
- low surface water turbulence = weak prediction

Water and sediment temperature

Predicted vs. actual bed elevation

RMSE = 0.6 cm
South Fork Boise River: Field application

http://www.southforkboise.org/
South Fork Boise River: Field data analysis

Water and sediment temperature

South Fork Boise River bed erosion

Temperature (deg C)

Relative bed elevation (cm)

Timestep 800:1800

Timestep (15 min)
Conclusions

• Temperature tracer economical and robust
• Field and laboratory analyses demonstrate positive results
• Engineering and Ecological applications
  ➢ real time monitoring scour-deposition
  ➢ surface-subsurface fluxes
  ➢ effective thermal diffusivity
  ➢ thermal regime of the sediment
Thank you!

Questions?